



COD ON THE SOUTHERN SCOTIAN SHELF AND IN THE BAY OF FUNDY (DIV. 4X/5Y)



Context

Cod has supported a commercial fishery in the 4X/5Y area since the 1700s. Following extension of jurisdiction to 200 miles by coastal states in 1977, only Canada has made substantial landings of cod from this area. Minimum mesh size and hook size regulations have been enacted to reduce the catch of small cod. Closure of Browns Bank is in place from 1 February-15 June.

The last assessment for this stock was conducted in 2006. Until 2003, the assessment of the stock was based on a population model using catch and abundance indicators. Recent assessments were based on trends in abundance indicators.

The present assessment is the result of a request for science advice from the Fisheries and Aquaculture Management (FAM) Branch (Maritimes Region). The main objectives were to evaluate the status of the stock and to provide scientific advice concerning conservation outcomes related to various fishery management options.

The current evaluation of the stock was conducted through a zonal assessment process where the status of 5 cod stocks in Atlantic Canada (2J3KL, 3Ps, 3Pn 4RS, 4TVn and 4X/5Y cod) was assessed. The meeting was held February 24 to March 6, 2009, in St. John's (NL). Participants included DFO Scientists, fisheries managers, officials of provincial governments, fishing industry members, external experts and academia.

SUMMARY

- The TAC was reduced to 5000 t in 2006. Landings have remained near 3,900 t and below the TAC since 2005.
- Biomass indices from surveys have remained low since 2000 when a rebuilding strategy was initiated.
- There is no indication of a decline in either total mortality or relative fishing mortality since 2000.
- A population model was used to provide estimates of abundance, fishing mortality and natural mortality for 4X cod.
- Mortality for causes other than reported landings, including natural mortality, for cod of ages 4 and older increased in 1996 and is currently 0.7 (46%). The high mortality greatly restricts productivity.
- A fishing mortality of 0.2 was adopted as a target for this stock during the 1980s. Fishing mortality has been above this level since 1980, and is currently 0.35.
- Spawning stock biomass (SSB) at the beginning of 2008 is 9,000 t; this is the lowest level in the time-series, which started in 1948.
- Recruitment for the 2006 and 2007 yearclasses are below average, but about twice the abundance of the very low 2003 and 2004 yearclasses.
- A SSB limit reference point (LRP) of 25,000 t has been adopted, because below this value the likelihood of poor recruitment increases.
- Projections indicate that at removals of 1,450 t in 2009 (management target of $F = 0.2$) some growth in SSB is expected; however, SSB is unlikely to reach the LRP of 25,000 t in 2010 even with no harvest.
- To be compliant with the principles of the precautionary approach, removals of cod from all fisheries should be reduced to the lowest possible level. This would imply substantial reductions in TAC below current catch levels, and additional measures to reduce cod catch in the mixed-species groundfish fisheries and cod by-catch in other fisheries.

INTRODUCTION

Species Biology

Atlantic cod (*Gadus morhua*) is a bottom dwelling North Atlantic fish. Cod range from Georges Bank to northern Labrador in the Canadian Atlantic. There are several concentrations of cod within this range, including those on the southern Scotian Shelf and Bay of Fundy in NAFO Divisions 4X and 5Y. Cod in this management unit comprise a stock complex. The degree of mixing amongst components is too great to resolve them into separate assessment units; however, the possibility of over-exploiting some components of the resource through concentration of the fishery remains a concern.

Juvenile cod feed on a wide variety of invertebrates and, as they grow, include fish in their diet. Seasonal movements associated with spawning occur and a number of spawning areas exist in this management area. Cod in this area reach on average 53 cm (21 inches) by age 3 years and increase to 72 cm (29 inches) by age 5 and 110 cm (43 inches) by age 10. Growth rates, however, vary, with more rapid growth noted for cod in the Bay of Fundy. Age at first reproduction generally occurs at 3 years and individuals tend to spawn several batches of eggs during a single spawning period. Biomass for ages 4 and older has been considered to best reflect the spawning stock biomass (SSB) since the contribution of first-time spawners per unit biomass is much less.

Oceanography

Oceanographic conditions within the 4X area have been quite variable in recent years, but do not display any long-term trends. Bottom temperature from the research vessel survey series was amongst the highest in the series in 2006, among the lowest in the series in 2007 and near average in 2008.

Other Species

Several other commercially fished species in 4X have shown long-term declining trends and are near the lowest levels observed in the research vessel survey series; these include monkfish, wolffish and white hake. This pattern of declining abundance is not universal. Survey catches of haddock show no recent trend and remain high, while catches of halibut, winter flounder, pollock and redfish have all increased in recent years, with some at the highest level in the survey series.

Data on cod diet show herring are the primary prey species, with silver hake and Cancer crabs of secondary importance. Survey catches of silver hake have been declining since the early 1980's and are at the lowest levels observed. Cancer crab catches have declined since 1999, when data collection commenced. Herring biomass in 4X was estimated to have been low from the mid-1990's until 2006 in the most recent assessment.

The major predators for cod are seals and other cod. Seal abundance in 4X has increased. Gray seal colonies have been established in recent years along SW Nova Scotia and New Brunswick. Abundance on Sable Island has increased to very high levels. These seals spread throughout the 4X area seasonally for feeding.

Fishery

Landings* (000s t)

Year	1970-1979	1980-1989	1990-1999	2000-2004	2005	2006	2007	2008
	1979	1989	1999	2004				
	Avg	Avg	Avg	Avg				
TAC	-	23.4	15.4	6	5.5	5	5	5
Total	22.5	24.9	15.2	5.6	3.9	3.7	3.9	

*Commencing in 2000, fishing year, landings and TAC refer to the period April 1st of the current year to March 31st of the following year

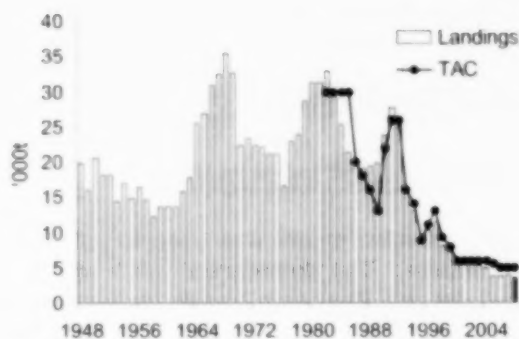


Figure 1. Landings* and TAC for 4X cod by quota year.

Cod is captured as part of a mixed species fishery in 4X along with haddock, pollock, redfish, winter flounder and several other groundfish species. In the 1960s, cod **landings** increased as domestic and foreign otter trawl fleets joined the predominantly hook and line fishery (Fig. 1), then dropped in 1970 as effort declined due to restrictions on haddock fishing. Landings declined through the 1990's as the total allowable catch (TAC) was reduced. The TAC was set at 6,000t for three years, starting in 2000, to promote an increase in biomass. This was not successful; biomass continued to decline, and the TAC was further reduced to 5000 t in 2006. Landings have remained near 3,900 t and below the TAC since 2005 (Fig. 1). As of March 1st, 3,800 t of the 2008 quota had been landed. With the low quotas, many participants in the fishery are reserving cod as a bycatch in other directed fisheries.

The distribution of the fishery has shifted in the last 5 years, with less of the landings coming from Western 4X (4Xqrs5Y). The proportion of landings taken in 4Xp in 2008 is among the highest observed in the time series. (Fig. 2).

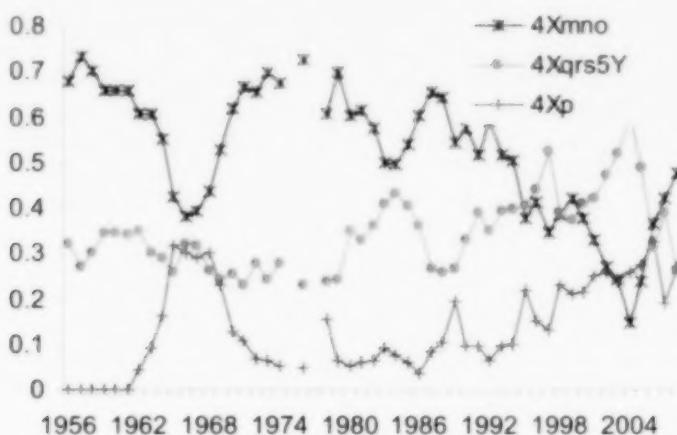


Figure 2. Proportion of cod landings by region.

Effort for all gear sectors peaked in 1992, and declined by about 50% by 1996. The number of active vessels, and the number of trips made has continued to decline in this fishery and the full quota has not been caught since 2002.

The 2003 yearclass has been dominant in the fishery in 2007 and 2008 and the 2004 yearclass has made little contribution. The contribution of cod over age 6 to the landings has been very low in the last decade.

ASSESSMENT

Sources of Information

A population model was used to provide estimates of abundance, fishing mortality and natural mortality. The commercial catch at age is included from 1980 to 2008. Indices used in the model are Research Vessel survey indices for ages 2 – 8 for 1983 - 2008, and ITQ survey indices for ages 1 – 8 for 1996 – 2008. The ITQ survey is a joint industry/DFO Science resource survey. It is a fixed station survey conducted on small otter trawlers using a balloon trawl with the same 19 mm codend liner as is used in the RV survey.

Biological Information

Many characteristics of cod growth and life history differ between cod in Eastern and Western 4X. Condition factor for cod in Western 4X shows no trend, but has declined from average levels for cod in Eastern 4X in the past four years, and in 2008 is the second lowest observed. Lengths at age for 4X cod captured in the RV survey are stable for both regions from 1970 to the present.

Stock Trends

Biomass indices from surveys have remained low since 2000 when a rebuilding strategy was initiated. On the Scotian Shelf, the research vessel (RV) survey **biomass index** has been declining since the late 1990s and has remained very low since 2003 (Fig. 3). The ITQ survey biomass index has varied without trend for the last decade.

In the Bay of Fundy the RV and ITQ survey biomass indices have both declined since quotas were dropped in 2000 to promote rebuilding. The biomass indices in the Bay of Fundy in 2008 were among the lowest in the series for both surveys (Fig. 3).

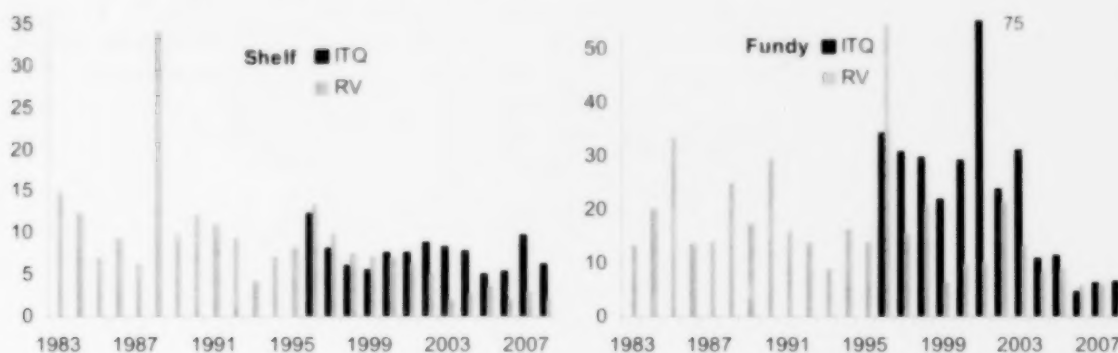


Figure 3. RV and ITQ survey biomass indices (Kg/tow) for 4X cod on the Scotian Shelf and in the Bay of Fundy (ITQ survey catch in 2001 = 75 kg/tow).

In 2008, RV survey **indices at age** are below the median for all ages (Fig. 4). Age 2 (the 2006 yearclass) was most abundant in the 2008 survey, and there were very few fish older than age 5.

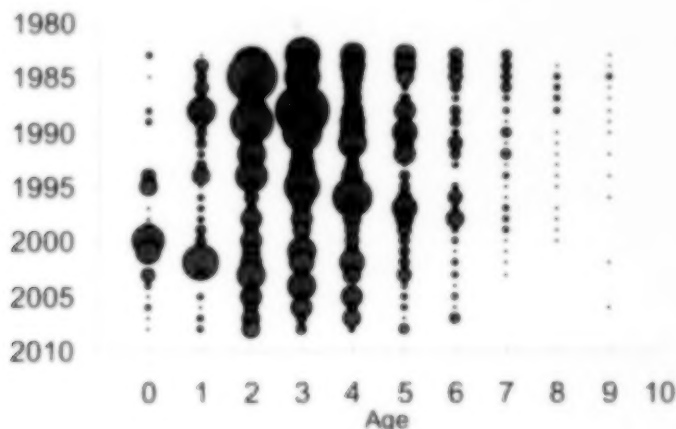


Figure 4. RV survey indices at age by area for 4X cod (bubble area proportional to abundance).

ITQ survey indices at ages 1 and 2 shows little trend over time but are both above the median for the series in 2008. The 2006 and 2007 yearclasses appear stronger than either the 2004 or 2005 yearclasses. As with the RV survey, indices for all older ages are low recently (Fig. 5).

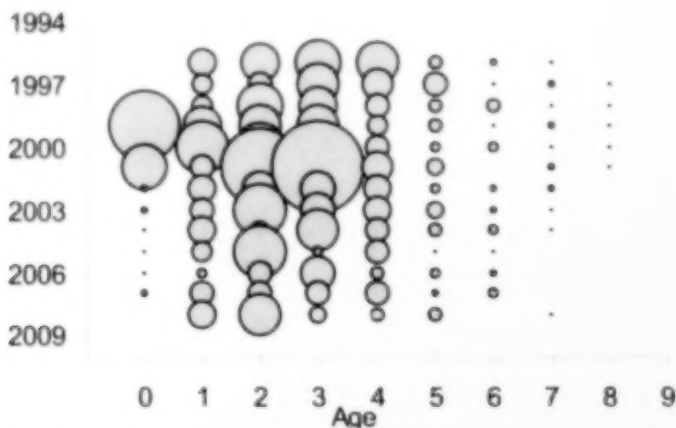


Figure 5. ITQ survey indices at age for 4X cod (bubble area proportional to abundance).

The **relative fishing mortality** (catch biomass/survey biomass index), while generally lower since 1995 than in the previous decade, has not declined despite the reduction in the TAC to 6,000 t in 2000. **Total mortality (Z)**, calculated from the RV survey, has been high in recent years on ages 4 and over. The total mortality calculated for the ITQ survey is variable without trend. The absence of a decline in total mortality or relative fishing mortality indicates that the TAC reduction has not led to a reduction in mortality.

Current Status

Results of an analytical assessment for this stock indicate that mortality for causes other than reported landings, including natural mortality, for cod of 4 years and older increased in 1996 and is currently 0.7 (46%). The high mortality greatly restricts productivity. This includes mortality from all factors other than reported landings, and could include discards and unreported landings as well as natural mortality from predators such as seals.

A fishing mortality of 0.2 was adopted as the target for this stock during the 1980s. Fishing mortality has been above this level since 1980, and is currently 0.35.

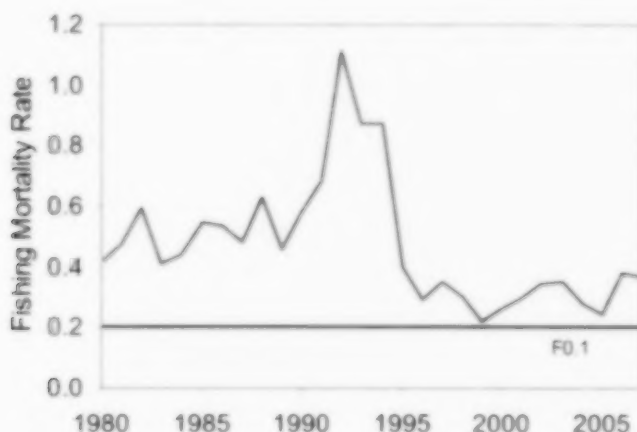


Figure 6. Fishing mortality rate for 4X cod.

There has been a general decline in biomass throughout the period assessed. The relatively strong 1985, 1987 and 1992 yearclasses resulted in only short-term improvements in biomass. SSB at the beginning of 2008 is 9,000 t; this is the lowest level in the time-series, which started in 1948.

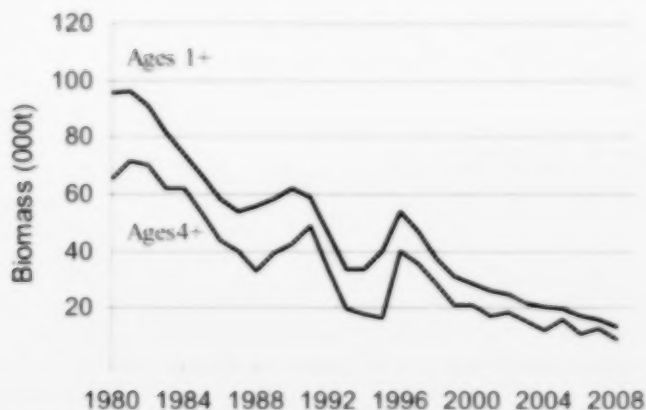


Figure 7: Total and spawning stock biomass estimates derived from population models for 4X cod.

Recruitment above 20 million was common in the 1980's; since the 1992 yearclass, no recruitment has approached this level. Recruitment for the 2006 and 2007 yearclasses are below average, but about twice the abundance of the very low 2003 and 2004 yearclasses.

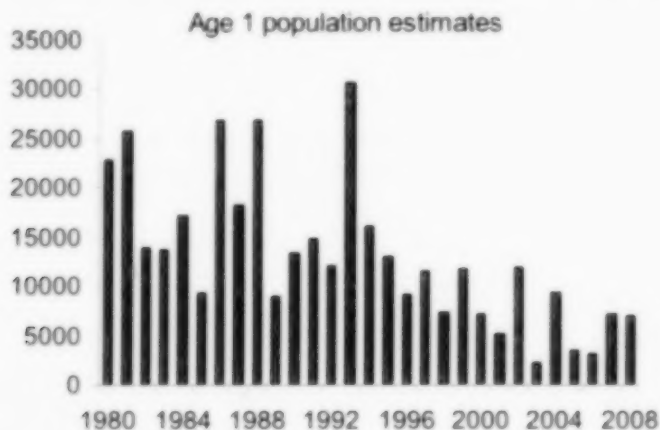


Figure 8. Recruitment estimates (age 1 '000s) for 4X cod.

A SSB limit reference point (LRP) of 25,000 t has been adopted, because below this value the likelihood of poor recruitment increases. Projections for this resource indicate that at removals of 1,450 t in 2009 (management target of $F = 0.2$) there is a >95% probability of at least 10% growth in SSB however, SSB is unlikely to reach the LRP of 25,000 t in 2010 even with no harvest.

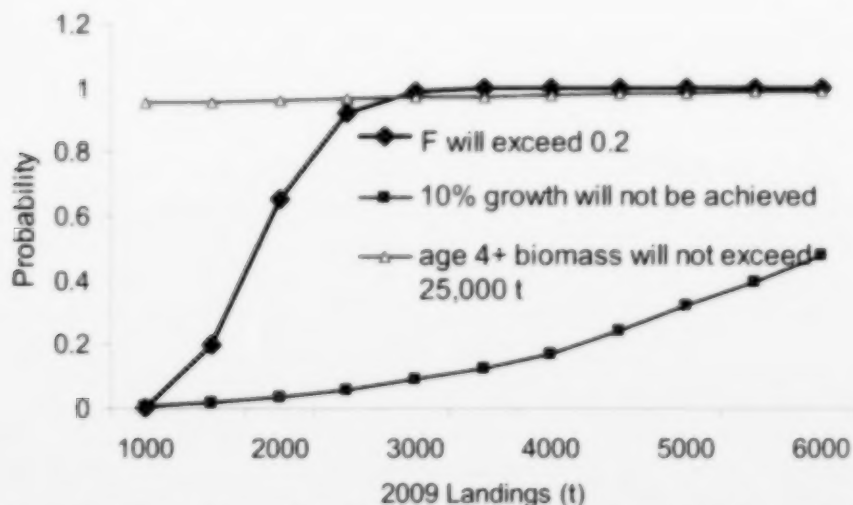


Figure 9. Risk of exceeding the target fishing mortality rate, of not achieving 10% growth in SSB and of not exceeding the LRP of 25,000t SSB for various catch levels in 2009.

Sources of Uncertainty

Cod in 4X are a stock complex. Trends may differ among components, complicating the interpretation of overall trends and leading to increased uncertainty.

The cause of high natural mortality in recent years is not clearly understood. While seal abundance has increased in 4X, the contribution of predation by seals to natural mortality for cod is not known. Misreporting and discarding of cod in 4X can contribute to the estimate of natural mortality. There were numerous reports of cod being discarded or landed unreported in

2000 and 2001 to avoid exceeding the quota. This is thought to have decreased in 2002 and since then there have been few reports from industry of misreporting and discarding.

Unrecorded removals from other fisheries will have some impact on total mortality. The extent of this is unknown but could be significant at low population levels.

ADDITIONAL STAKEHOLDER PERSPECTIVES

No additional stakeholder perspectives were provided.

CONCLUSIONS AND ADVICE

Biomass has remained low since 2000 when the quota was reduced to 6,000 t to promote rebuilding. There is no indication of a decline in total mortality or relative fishing mortality since 2000. Natural mortality is estimated to have increased to 0.7 and this greatly restricts productivity. Landings of about 3,900 t in recent years have contributed to a continuing decline in abundance, and biomass is projected to have declined further from 2008 to 2009. Survey recruitment estimates for the 2006 and 2007 yearclasses are improved over the preceding two yearclasses, and should result in an increase in stock biomass in the short-term.

A yield of 1,450 t in 2009 would be consistent with the target exploitation rate of 16.5%. At this yield, there is a high probability of 10% growth in SSB (>95%) between 2009 and 2010; however, this will only return the SSB to about the same level as in 2008. To be compliant with the principles of the precautionary approach, removals of cod from all fisheries should be reduced to the lowest possible level. This would imply substantial reductions in TAC below current catch levels, and additional measures to reduce cod catch in the mixed-species groundfish fisheries and cod by-catch in other fisheries.

OTHER CONSIDERATIONS

Cod in 4X are harvested as part of a mixed species groundfish fishery. With current fishing practices and species catch ratios, achieving rebuilding objectives for cod may constrain the harvesting of other groundfish. An imbalance in quotas creates potential for discarding and may require improved monitoring. Modifications to fishing gear and practices, with enhanced monitoring, may mitigate these concerns.

SOURCES OF INFORMATION

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